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Title of the Invention: Liquid Crystal Display and Manufacturing Method for Same

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(transliterated, therefore the spelling might be incorrect)

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(54)[Title of the Invention] Liquid Crystal Display and Manufacturing Method for Same

(57)[Abstract]
[Object] A liquid crystal display having high display quality, where the reliability of the switching operation of thin film transistors is increased, as well as a manufacturing method for the same, are provided.

[Means for Achieving Object] A gate electrode 13 is formed above a polycrystal silicon film 11 on a translucent substrate 4 via a gate insulating film, and impurity is doped into polycrystal silicon film 11 so as to form a source region 15 and a drain region 16. Next, a source electrode 18 and a drain electrode 19 for electrical connection of source region 15 and drain region 16 are formed above these regions via an interlayer insulating film 17, and these electrodes are covered with silicon oxide fluoride film 20. A pixel electrode 9 connected to drain electrode 19 is formed on silicon oxide fluoride film 20. In an LCD that has been manufactured according to such a method, transmittance of the silicon oxide fluoride film is high and the dielectric constant is low, and therefore, display quality is increased, in comparison with the prior art.

[Claims]

1. A liquid crystal display, comprising:

a first substrate having, on its surface, a thin film transistor where a channel portion, a source region and a drain region are formed in a deposited polycrystal silicon film and a gate electrode is formed above the channel portion via a gate insulating film, and a pixel electrode that defines an opening for a pixel;

a second substrate having, on its surface, an opposite electrode that faces the first substrate; and

a liquid crystal layer which intervenes between the first substrate and the second substrate, characterized in that

a silicon oxide fluoride film is formed on said thin film transistor and the opening and the polycrystal silicon film includes fluorine.

2. A manufacturing method for a liquid crystal display which comprises:

a first substrate having, on its surface, a thin film transistor where a channel portion, a source region and a drain region are formed in a deposited polycrystal silicon film and a gate electrode is formed above the channel portion via a gate insulating film, and a pixel electrode that defines an opening for a pixel;

a second substrate having, on its surface, an opposite electrode that faces the first substrate; and

a liquid crystal layer which intervenes between the first substrate and the second substrate, characterized by comprising the steps of:

forming a polycrystal silicon film on a predetermined region of a first substrate, forming a channel portion, a source region and a drain region in the polycrystal silicon film, and forming a gate electrode above the channel portion via a gate insulating film, thus forming a thin film transistor;

forming a silicon oxide fluoride film that includes fluorine on the thin film transistor and the opening according to a CVD method; and

carrying out heat treatment on the silicon oxide fluoride film so that fluorine is diffused into the polycrystal silicon film.

[Detailed Description of the Invention]

[0001]

[Technical Field to Which the Invention Pertains] The present invention relates to a liquid crystal display (LCD) where TFT (thin film transistor) elements having channel portions, source regions and drain regions formed in polycrystal silicon (poly-Si) films are used as

switching elements, as well as a manufacturing method for the same.

[0002]

[Prior Art] A polycrystal silicon film includes a great number of silicon atoms having dangling bonds, and in the case where a TFT element is manufactured in such a manner that the dangling bonds remain, the switching operation is negatively affected, and this problem is solved according to the following method.

[0003] A manufacturing method for a field effect type TFT element having a silicon nitride film is described in Japanese Patent Publication No. H4(1992)-57098. This TFT element is manufactured by forming a channel portion, a source region and a drain region in a polycrystal silicon film on a substrate, by forming a gate electrode above the channel portion, and by covering the substrate that includes the polycrystal silicon film having the channel portion with a silicon nitride film, the source region and the drain region, and the gate electrode. The silicon nitride film that is formed according to a plasma CVD method includes a microscopic amount of hydrogen, and the internal hydrogen diffuses into the polycrystal silicon film by means of heat treatment at approximately 400°C. As described above, the silicon nitride film serves as a passivation film for the TFT element, and at the same time, serves as a hydrogen supply source for diffusing hydrogen into the polycrystal silicon film so as to annul the dangling bonds through the formation of Si-H bonds.

[0004] A manufacturing method for a TFT element by implanting hydrogen, fluorine or chlorine into a silicon film is described in Japanese Unexamined Patent Publication No. H7(1995)-288329. According to this method, at least one element selected from among hydrogen,

fluorine and chlorine is ionized, and is implanted into a silicon film formed on a glass substrate so that the ions are bonded to the dangling bonds in the silicon film, annulling the dangling bonds.

[0005]

[Problem to Be Solved by the Invention] In an LCD using TFT elements that has been manufactured according to the method of Japanese Patent Publication No. H4(1992)-57098, light transmittance of the silicon nitride film is comparatively low, and thereby, display quality is lowered. In addition, the dielectric constant of the silicon nitride film is comparatively high, increasing the parasitic capacitance, and thereby, cross-talk occurs, decreasing display quality. Furthermore, Si-H bonds have a comparatively low bonding energy, allowing the occurrence of hydrogen separation when used at a comparatively high temperature, and therefore, reliability of the switching operation of the TFT elements is lowered.

[0006] In a TFT element that has been manufactured according to the method of Japanese Unexamined Patent Publication H7 (1995)-288329, after the gate insulating film has been formed, hydrogen, fluorine or chlorine ions are implanted into the silicon film so that the ions are bonded to the dangling bonds, and therefore, a process at a high temperature, for example, at 500°C, cannot be carried out in order to avoid the separation of hydrogen, fluorine or chlorine in the subsequent process. In addition, an ion implantation technique is used, breaking the crystallinity of the polycrystal silicon at the time of the ion implantation, and therefore, the crystallinity of the polycrystal silicon cannot be recovered, even by means of the subsequent annealing, thus deteriorating reliability of the operation of the TFT element. In the

case where such a TFT element is used for an LCD, a problem may arise with the reliability of the operation of the TFT element, and the display quality of the LCD may be negatively affected.

[0007] An object of the present invention is to provide a liquid crystal display having high display quality where the reliability of the switching operation of thin film transistors is increased, as well as a manufacturing method for the same.

[0008]

[Means for Solving Problem] The present invention provides a liquid crystal display, comprising: a first substrate having, on its surface, a thin film transistor where a channel portion, a source region and a drain region are formed in a deposited polycrystal silicon film and a gate electrode is formed above the channel portion via a gate insulating film, and a pixel electrode that defines an opening for a pixel; a second substrate having, on its surface, an opposite electrode that faces the first substrate; and a liquid crystal layer which intervenes between the first substrate and the second substrate, characterized in that a silicon oxide fluoride film is formed on the above described thin film transistor and the opening and the polycrystal silicon film includes fluorine. According to the present invention, a silicon oxide fluoride film is utilized, and thereby, transmittance of the opening in the liquid crystal display can be improved, increasing display quality. In addition, the silicon oxide fluoride film has a low dielectric constant in comparison with a conventional passivation film such as a silicon nitride film, reducing the parasitic capacitance, and thereby, cross-talk can be reduced, increasing display quality. Furthermore, the polycrystal silicon film

includes Si-F bonds having a high bonding strength inside, and therefore, reliability of the operation of the liquid crystal display can be increased in comparison with a conventional silicon film that includes Si-H bonds.

[0009] In addition, the present invention provides a manufacturing method for a liquid crystal display which comprises: a first substrate having, on its surface, a thin film transistor where a channel portion, a source region and a drain region are formed in a deposited polycrystal silicon film and a gate electrode is formed above the channel portion via a gate insulating film, and a pixel electrode that defines an opening for a pixel; a second substrate having, on its surface, an opposite electrode that faces the first substrate; and a liquid crystal layer which intervenes between the first substrate and the second substrate, characterized by comprising the step of: forming a polycrystal silicon film on a predetermined region of a first substrate, forming a channel portion, a source region and a drain region in the polycrystal silicon film, and forming a gate electrode above the channel portion via a gate insulating film, thus forming a thin film transistor; forming a silicon oxide fluoride film that includes fluorine on the thin film transistor and the opening according to a CVD method; and carrying out heat treatment on the silicon oxide fluoride film so that fluorine is diffused into the polycrystal silicon film. According to the present invention, fluorine in the silicon oxide fluoride film diffuses into the polycrystal silicon film by means of heat treatment, and is bonded to the dangling bonds, forming Si-F bonds that have a large bonding energy, and therefore, the characteristics of the switching operation of the thin film transistor are improved in comparison with a

conventional method for forming Si-H bonds. In a liquid crystal display that uses such a thin film transistor, display quality can be improved by reducing cross-talk or the like. In addition, the number of crystal defects in the polycrystal silicon film is small, making the manufacturing process easy and increasing the productivity in comparison with a conventional method for ionizing and implanting fluorine.

[0010]

[Preferred Embodiments of the Invention] Fig. 1 is a perspective view showing a portion of a configuration of a LCD 1 using TFT elements according to one embodiment of the present invention, and Fig. 2 is a plan view showing a portion of a configuration on a translucent substrate 4 of Fig. 1. The LCD 1 is formed of: a liquid crystal layer 2; a translucent substrate 3 and the translucent substrate 4 between which the liquid crystal layer 2 is sandwiched; and a polarizing plate 5 and a polarizing plate 6 between which the translucent substrate 3 and the translucent substrate 4, between which the liquid crystal layer 2 is sandwiched, are further sandwiched. The translucent substrate 4 has signal lines 8, pixel electrodes 9, and TFT elements 10 for connecting the signal lines 8 to the pixel electrodes 9 on the liquid crystal layer 2 side. The translucent substrate 3 has a color filter 31 on the liquid crystal layer 2 side, and an opposite electrode 7 in plain form on top of the filter. The signal lines 8 transmit signals for display, the TFT elements 10 control conduction between the signal lines 8 and the pixel electrodes 9, and the pixel electrodes 9 apply a predetermined voltage to the liquid crystal layer 2 between the pixel electrodes 9 and the opposite electrode 7.

[0011] In the LCD 1 of Fig. 1, an external driving circuit, not shown, selects a pixel electrode 9 to which a signal for display is to be supplied. A predetermined voltage is applied to the liquid crystal layer 2 between the selected pixel electrode 9 and the opposite electrode 7. The orientation condition of liquid crystal molecules are changed so that light transmittance can be controlled through the application of the voltage. Light transmittance is controlled by this orientation condition of the liquid crystal molecules, and thereby, the condition of the pixel for display is controlled.

[0012] Figs. 3(a) to 3(e) are cross-sectional views showing the formation on the translucent substrate 4 of Fig. 1 in each step of the manufacturing process. In Fig. 3(a), polycrystal silicon is deposited on translucent substrate 4, and this is patterned into islands, forming polycrystal silicon films 11. Silicon oxide is deposited on the translucent substrate 4 and the polycrystal silicon film 11 according to a CVD method so as to have a thickness of 50 nm, forming a gate insulating film 12.

[0013] In Fig. 3(b), a gate electrode 13 is formed of, for example, polycrystal silicon into which impurity has been doped, above the polycrystal silicon film 11 via the gate insulating film 12. Next, impurity ions are implanted into the polycrystal silicon film 11 using the gate electrode 13 as a mask. In the case where an N-channel TFT element is formed, for example, phosphorus is implanted, and in the case where a P-channel TFT element is formed, boron is implanted. The portion which is not doped because of the gate electrode 13 becomes a channel portion 14, while the portions that have been doped become a source region 15 and a drain region 16.

[0014] In Fig. 3(c), silicon oxide is deposited on the

gate electrode 13 and the gate insulating film 12 according to a CVD method so as to have a thickness of 500 nm, forming an interlayer insulating film 17. Next, contact holes are created in the interlayer insulating film 17 and the gate insulating film 12, above the source region 15 and the drain region 16, respectively, and a source electrode 18 and a drain electrode 19 are formed of Al, by filling the respective contact holes.

[0015] In Fig. 3(d), silicon oxide fluoride is adhered to the interlayer insulating film 17, the source electrode 18 and the drain electrode 19 according to a plasma CVD method, so as to form a silicon oxide fluoride film 20 having a thickness of 40 nm. Here, as for the condition of the plasma CVD, TEOS (tetraethoxy silane) having a flow of 400 sccm and CF_4 having a flow of 200 sccm are used as generation gases, the RF power is set at 2 W/cm^2, the pressure is set at 10 mTorr, and the temperature is set at 350°C.

[0016] Here, a gas that includes fluorine atoms such as C_2F_6, C_3F_8, NF_3 or HF may be used in place of CF_4. In addition, a silane-based gas such as SiH_4, Si_2H_6, Si_3H_8, SiF_4 or SiH_2F2, or an organic silane gas such as $FSi(OC_2H_5)_3$ (fluorotriethoxy silane) may be used in place of TEOS.

[0017] Next, the temperature is set at a high temperature, for example, 400°C, and thereby, fluorine that is included in silicon oxide fluoride film 20 is diffused into polycrystal silicon film 11, and at the same time, polycrystal silicon film 11 is annealed, recovering the crystallinity. Here, fluorine may be primarily diffused into channel portion 14 within polycrystal silicon film 11, and may furthermore be diffused into the source region 15 and the drain region 16. In such a manner, fluorine is bonded to the dangling bonds in polycrystal silicon film

11, so as to annul the dangling bonds by forming Si-F bonds. Si-F bonds have bonding energy of 5.7 eV, which is a higher bonding strength than that of Si-H bonds in the prior art, of which the bonding energy is 3.1 eV.

[0018] In Fig. 3(e), a contact hole is created in the silicon oxide fluoride film 20, above the drain electrode 19. Next, the transparent pixel electrode 9 is formed on the region of the silicon oxide fluoride film 20 other than the region above the polycrystal silicon film 11, so as to be connected to the drain electrode 19 through this contact hole.

[0019]

[Table 1]

Wavelength (nm)	400	500	600	700	800
Silicon nitride	40%	90%	90%	90%	90%
Silicon oxide fluoride	90%	90%	90%	90%	90%

[0020] Table 1 shows transmittances of silicon nitride and silicon oxide fluoride for each wavelength. The thicknesses of the silicon nitride film and the silicon oxide fluoride film are both 40 nm. The silicon oxide fluoride film exhibits a transmittance higher than that of the silicon nitride film according to the prior art in the wavelength range from 400 nm to 800 nm which is required for an LCD, in particular, in the wavelength range from 400 nm to 500 nm.

[0021] In addition, as for the relative dielectric constant of each material, silicon oxide fluoride has a value in a range from 3.0 to 3.8, silicon nitride that has been formed as a film according to a reduced pressure CVD method has a value in a range from 6 to 7, silicon nitride that has been formed as a film according to a plasma CVD method, has a value in a range from 6 to 9 and silicon oxide has a value in a range from 3.9 to 5.0. Above

described above, the relative dielectric constant of silicon oxide fluoride is smaller than those of silicon nitride and silicon oxide. Accordingly, in the case where LCD 1 is manufactured as shown in Fig. 3, the parasitic capacitances which occur in interlayer insulating film 17 and in silicon oxide fluoride film 20, are reduced in comparison with the prior art and, thus, cross-talk is reduced, improving the display quality of the LCD.

[0022]

[Effects of the Invention] As described above, according to the present invention, silicon oxide fluoride can be utilized so that the transmittance is increased and the parasitic capacitance is reduced and, thereby, display quality of the liquid crystal display can be improved. In addition, fluorine is diffused into the polycrystal silicon film, which is then stabilized, by means of heat treatment so that reliability in the switching operation of the thin film transistors can be increased and display quality of the liquid crystal display can be improved. Furthermore, the manufacturing process can be simplified more than the prior art, thus increasing the productivity.

[Brief Description of the Drawings]

[Fig. 1] A perspective view showing a configuration of a portion of a LCD 1 according to one embodiment of the present invention.

[Fig. 2] A plan view showing a configuration of a portion on a translucent substrate 4 of Fig. 1.

[Fig. 3] A cross-sectional views showing the formation on the translucent substrate 4 of Fig. 1 in each step of the manufacturing process.

[Explanation of Symbols]

1 LCD

2 liquid crystal layer

3, 4 translucent substrates
7 opposite electrode
9 pixel electrodes
10 TFT elements
11 polycrystal silicon film
12 gate insulating film
13 gate electrode
14 channel portion
15 source region
16 drain region
20 silicon oxide fluoride film